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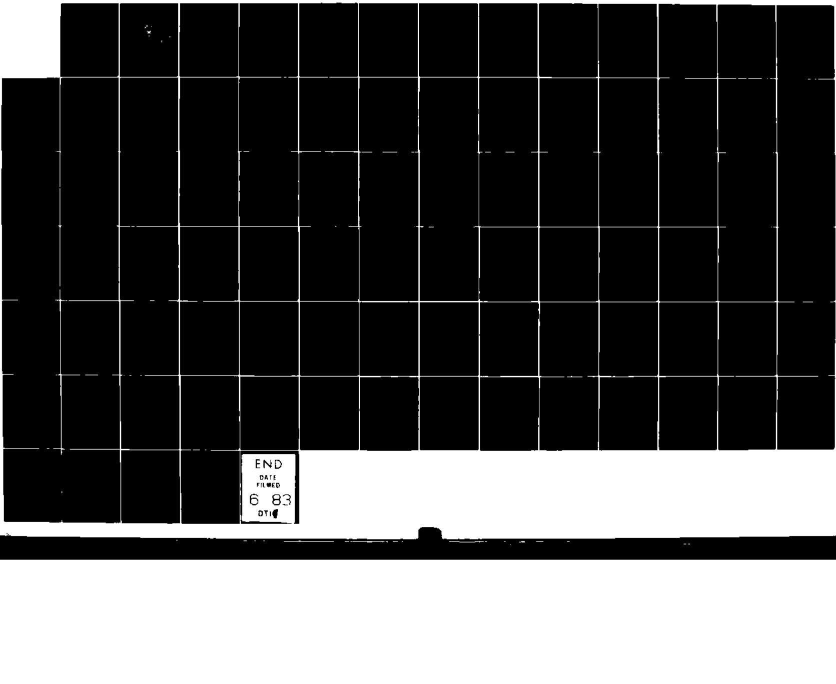

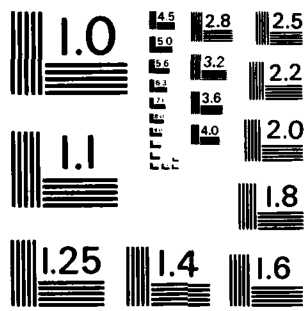
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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

Management Principles to be Considered for
Implementing a Data Base Management System
Aboard U.S. Naval Ships Under the
Shipboard Non-tactical ADP Program

by

Robert Harrison Dixon

December 1982

Thesis Advisor: Norman R. Lyons

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The increased administrative burden being placed upon the Fleet increasingly affects ship performance and personnel morale and retention. The Shipboard Non-tactical ADP Program (SNAP) is being instituted in order to alleviate these burdens. However, the "applications approach" being used with SNAP is not sufficient to meet both the functional and management needs of the Fleet. The management environment necessary to satisfy both of these needs are discussed. The central theme is that of centralization and standardization of data, its definition, and its control. Fundamental to the

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above philosophy is the concept of Information Resource Management (IRM). Automation of IRM should be done via a Data Base Management System (DBMS). The critical tool required to transfer IRM results to a DBMS is the Data Dictionary System (DDS). Additionally, two crucial management positions, the IRM manager and the Data Base Administrator (DBA), are essential to the success of this "data base approach."

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Management Principles to be Considered for Implementing a Data Base Management System Aboard U.S. Naval Ships Under the Shipboard Non-tactical ADP Program

by

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I. INTRODUCTION

A. BACKGROUND

The shipboard non-tactical automated data processing (ADP) program (SNAP) was initiated in response to CNO objective No. 5, which required the alleviation of the administrative burden on the Fleet. The constantly increasing rate of peace-time administrative requirements, coupled with the reduction of shipboard manning levels, has significantly reduced Fleet effectiveness by increasing the administrative burden on the Fleet to an unmanageable level. Although many ships and shore installations use computers to fulfill administrative needs, the administrative burden is still present because the computers have been around since the mid-1960's and their operation is very machine dependent. Additionally, the smaller operating units of the Fleet are still trying to accomplish the excessive administrative requirements manually. Thus, there is a need to insure "(1) data/information is collected only once at the shipboard level and maintained and utilized for shipboard functions; (2) minimum upline reporting with shorebased initiated automated reconciliation of shipboard data/information; and (3) maximum automated interface with other

Fleet or shore supporting automated information systems. An automated support capability that will assist shipboard personnel with their support functions and inherently provide for minimum, accurate, and timely data information update and exchange, will result in improved Fleet readiness, enhanced capability to meet all operational requirements and improved personnel morale and retention." [1: 2-4]

Officially, SNAP is "the automation of non-tactical requirements of Fleet operational and direct support units, afloat and ashore, which will employ uniform fleet non-tactical Automated Data Processing Equipment (ADPE)." [1: 2-2] SNAP I and SNAP II are the two subordinate projects underway to accomplish CNO objective No. 5. Both projects address the same areas: supply/fiscal, maintenance, and personnel. However, the main thrust of SNAP I is to replace the AN/UYK-5(V) computer which has been supplying Fleet non-tactical ADP since the mid-1960's for larger ships (e.g., CV, LHA), Marine Air Groups (MAGs), and shore activities. SNAP II, on the other hand, is aimed at automating supply, maintenance, and personnel functions for smaller ships (e.g., FF, DD, CG), which are presently performing these functions manually. Both projects are being developed under separate contracts (Honeywell for SNAP I; Harris for SNAP II), but both systems will be able to interface with each other. Physical implementation will begin during the

1983/1984 time frame; and after complete implementation thousands of processors and tens of thousands of CRT terminals and printers will have been installed at both shore and afloat commands for both the Navy and the Marine Corps at a cost in excess of one billion dollars.

B. SNAP IS USING AN APPLICATIONS APPROACH

The development of a computer system can be viewed as following one of two approaches: an applications approach or a data base approach. [2] Under the applications approach computers are thought to be electronic filing systems which are designed to satisfy specific output requirements based on a set of pre-determined needs. The initial intention of the the data processing department in this environment is to develop the various computer applications required to fulfill the pre-determined needs. Once the applications are developed the function of the data processing department will be that of maintenance of the different applications.

The filing systems and the associated applications are developed for individual managers and departments. However the independent filing systems and application programs will have to be integrated because their dependencies upon each other are necessary for the attainment of the overall objectives and goals of the organization. This integration is

predictable because the organization's performance is dependent upon effective inter-relationships among the subordinate managers and departments. Thus, a two-fold problem will develop from this approach: (1) the necessity of integrating decentralized files and programs which are developed independently by different personnel; and (2) the integration effort will inevitably fall upon the data processing department whose function is basically the main-tenance of the files and programs, not the formulation of policy, creation of standards, and resolution of inter-departmental conflicts.

Appleton refers to this type of data processing environment where computers are used as electronic filing systems which receive, store, process, and report as the "application systems syndrome. This "sysndrome" is characterized by a set of assumptions made by management: [2: 86]

- Systems will be built for individual managers, not the company as a whole.
- Data processing input, storage, and processing techniques will be geared to specific output needs.
- The data processing environment will serve managers who want computers; i.e., it will evolve along the "path of least resistance."
- Investments for computer hardware, software, and personnel will be based on current demand for computer applications and will be increased as that demand increases.
- Automated systems will work manually before they can be computerized.

* The data processing department will have no responsibility for system or data integrity beyond writing programs that work.

* Justifications for data processing services will be based on cost trade-offs (most often personnel reductions), application by application, rather than by company plans to improve overall efficiency or productivity.

A review of the Mission Element Need Statement (MENS) for both SNAP I [1] and SNAP II [3] (summarized in the previous section) in context of the above "symptoms" of "application systems syndrome" indicate that an applications approach is being used with the SNAP program; i.e., a fixed number of master files will be developed to satisfy pre-determined functions, thereby locking beneficial data into the pre-determined applications for certain parts of the organization rather than making this data accessible for the benefit of the whole organization. At the time of this writing the SNAP administrative functions will be automated by using the file management facilities of the computer operating system. File manipulation will require complete applications programs; no ad hoc query capability will be implemented. Also, general updating of files will be performed by batched transactions.

The MENS for SNAP I alludes to a more sophisticated approach to development of the SNAP computer systems: "The management data needed is not available in a timely and

accurate manner to the operating managers. Effective management decisions are dependent upon accurate and timely management data. Such on-line, transaction driven, query interactive access to management data is not achievable as long as the status quo is maintained and cost-effective automated support is not provided." [1: 2-5] However, the more rudimentary applications approach is presently being used because it is felt that the experience and training of shipboard personnel is not sufficient to maintain a central data base (which is part of the more sophisticated "data base approach" to be addressed later) in a reliable condition.

As indicated above, the decision to forego the implementation of a Data Base Management System (DBMS) with SNAP was based on <u>technical limitations</u>.[1] The concept supported by this paper is that the predominant problems to be addressed when implementing a DBMS aboard ship under SNAP should be managerial. This is not to say that the problem of maintaining a reliable data base is not important, nor that maintaining a data base is as easy as maintaining "flat files." Maintenance of a reliable data base is more complex

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[1] Naval Air Logistics Command Information System (NALCOMIS) functions will be automated with a data base management system. However, development is being conducted under a separate program from SNAP I and SNAP II.

than maintaining "flat files," and the maintenance of reliable data in any approach to the development of a computer system is a significant consideration prior to implementation. However, overcoming technical, "cockpit" problems is relatively easier than the more abstract managerial problems that arise with computer systems development.

C. THE DATA BASE APPROACH

Since the operational and organizational environment of an organization constantly undergoes change, it stands to reason that information requirements of new operational procedures and new organizations are also dynamic. The applications approach basically supports static, routine information requirements. Thus, the limited ability to satisfy only specific functional needs does not account for changes to the management decision-making process. Therefore, a more versatile alternative to the applications approach is needed in order for computer automation to control the ability to respond efficiently and effectively to changing information needs. This more viable alternative is the data base approach.

A simplified explanation of the data base approach is that it entails the development of "an automated pool of accurate and timely data which could be easily and equally

drawn upon to satisfy, on demand, the information requirements of management's decision problems." [2: 85] The data base approach encompasses three types of data bases: (1) two or three central data bases that contain much of the organization's data and are commonly used: (2) several functional data bases that each contain data shared by a more limited set of programs; and (3) a small number of dedicated data bases that accomodate single applications. [4: 3] In order to implement these data bases, rather than developing input, storage, processing, and output techniques to satisfy specific pre-determined requirements (as does the applications approach), the data base approach consists of three basic control systems: (1) a data base input control system, (2) a data base output control system, and (3) a data base storage and processing system. [2: 87] These <u>control</u> systems differ from the <u>filing</u> systems of the applications approach in that they are essentially standardized for use by the entire organization rather than individually developed for each separate application.

The basic functions of the input control system (input techniques, edits, audits, security, and diagnostic controls) are intended to optimize data quality, integrity, and cost. Data is captured at its source with no regard as to its intended use. Once established, the input control system will not significantly change because it is not

subordinate to the company structure or to individual management prerogatives. The input control system would undergo change only if more or less data of higher or lower quality were required, or if technological advances made data input more efficient or cost effective.

Unlike the input control system, the output control system is subordinate to both company organization structure and specific management prerogatives. These dependencies enable a wide range of management decision-making needs to be fulfilled. Thus, output control systems are developed to support the dynamic world of output demand. Changes to the output control system are initiated by almost anything, such as personalities, management styles, economics, politics, changes in functional responsibilities, etc.

The storage and processing control system manages the data itself, receiving data from the input control system and passing it, on demand, to the output control system. The storage and processing control system controls the data base's physical structure, which is dynamic in nature because physical organization of the data depends on the different logical views of the data held by the users. Thus, changes to the system are made to optimize efficiency and cost effectiveness. The processing and control system is generally implemented with a data base management system

that has built-in capabilities to control backup and recovery, data availability, security and privacy, computer effiency, etc. Each occurance of a new application therefore does not need to develop these functions independently.

The successful implementation of a data base environment requires development within the following guidelines: [2: 92]

- The data base must be built for the whole company, not for individual managers.
- Data base development must follow a logical, well orchestrated plan, not the path of least resistance (i.e., use of the computer by only those managers who want to use it).
- Data processing must be intended to improve overall productivity by supplying accurate information based on management needs, not justified through cost reductions based on personnel placement.
- Management must concentrate primarily on identifying the information it needs to manage.
- A single entity must control what is stored on the computer and how.
- Company input responsibilities should be established and funded separately from output needs.
- The single entity in control of the data base must be given increased responsibility for input control and data integrity and accordingly, authority for defining and obtaining required input.
- Investments in hardware, software, and personnel must be based on the needs of the data base control systems, not on requirements for specific applications.

D. THESIS PURPOSE AND ORGANIZATION

This paper is written on the premise that, given use of the applications approach to data base development, shipboard use of non-tactical ADP will follow the traditional computer system development cycle illustrated in Figure 1 as user knowledge and experience increases with exposure to the ADP environment.[2] Note that the initial stages of development employ an applications approach, whereas the latter stages use the data base approach. However, because the applications approach and the data base approach support independent philosophies, the initial use of an applications approach is not a pre-requisite for the data base approach. In fact, the transition from an applications approach to a data base approach will prove costly and disruptive to an organization. Additionally, the global characteristics of the data base approach result in a more "user friendly" environment that expands the objectives of the applications approach to an organization-wide basis. Therefore, the purpose of this paper is to explain that a data base approach to SNAP system development is a more effective response to CNO Objective No. 5, and to outline the

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[2]The S-shaped curve in Figure 1 represents ADP expenditures. This continual increase in capital outlay for computer systems illustrate the increased importance of information processing to organizational management.

Growth processes						
Applications portfolio	Functional Cost Reduction Applications	Proliferation	Upgrade documentation and restructuring of existing applications	Retrofitting existing applications using data base technology	Organization integration of Applications	Application integration "mirroring" information flows
DP organization	Specialization for technological learning	User-oriented programmers	Middle management	Establish computer utility and user account teams	Data administration	Data resource management
DP planning and control	Lax	More lax	Formalized planning and control	Tailored planning and control systems	Shared data and common systems	Data resource strategic planning
User awareness	"Hands off"	Superficially enthusiastic	Arbitrarily held accountable	Accountability learning	Effectively accountable	Acceptance of joint user and data processing accountability
	Stage I Initiation	Stage II Contagion	Stage III Control	Stage IV Integration	Stage V Data administration	Stage VI Maturity

Six Stages of Data Processing Growth

Figure 1 [5: 117]

managerial framework in which a data base approach should be conducted.

The fundamental managerial concept underlying the data base approach is that data (and the information generated from data) is an organizational resource, and is not part of particular applications system under the cognizance of individual line managers. This concept of Information Resource Management (IRM), and the "IRM executive" who coordinates the selection and placement of data in the organizational data bases, is discussed in Chapter II.

In order to effectively support automation within the data base approach, most of the organizational data will have to be centralized. With data centralization, data is no longer owned by individual managers. Instead, individual interests become subordinate to to the organization as a whole, and managers will become more dependent upon their peers and other departments. The primary tool to define, catalogue, and identify relationships in the centralized data is the Data Directory System (DDS), addressed in Chapter III.

The IRM concept establishes data/information as an organizational resource. The DDS is the primary tool in controlling this resource. However, "some sort of information system is needed. That class of systems have come to

be known as data base management systems." [6: ID/21] Data Base Management Systems (DBMSs) are more compatible with IRM and DDS than traditional file management systems used in the applications approach because a DBMS is designed to enable centralized files of data to be shared by various users. The advantages of DBMSs over applications systems is discussed in Chapter IV.

Finally, under the data base approach, the IRM executive deals with upper level management of data and information necessary to fulfill organizational goals and objectives. However, an additional manager is also needed to be the custodian of the physical data base resulting from the efforts of the IRM executive. This person is the creator and enforcer of standards and policies relating to the use of the DBMS, DDS, and other computer-related equipment. These duties constitute the Data Base Administrator (DBA) function, and are addressed in Chapter V.

II. INFORMATION RESOURCE MANAGEMENT

The main functions of the Combat Information Center (CIC) aboard ship are the collection, processing, display, evaluation, and dissemination of information. Standard, Navy-wide procedures for executing these functions are found in a multitude of directives and publications. Through this documentation, a methodology is established whereby masses of input data are converted to relevant information that is necessary for the ship to carry out its assigned mission. This standardization of information handling results in information flows which are understood by all personnel because the effectiveness of the ship *as a whole* is being enhanced. A similar situation can be seen with the ship's Damage Control (DC) procedures.

The urgency of quick, and correct, actions required of a ship in various combat and non-combat situations is the impetus for establishing concrete information policies referred to above. Handling of information in this manner exemplifies the concept of Information Resource Management (IRM). With the implementation of SNAP, the capability will exist to extend this IRM concept to the "total ship."

Strict guidelines for information handling have to be developed just as for the more tangible resources of money, people, and material because the fast-paced, dynamic environment characterized by complex technological advances have created what Forest W. Horton, Jr. terms an "information explosion." [7: 1] On the other hand, "the demand for data, like the demand for dollars, or people, or supplies, or office space, tends to exceed supply." [7: 22] How then can the "information explosion" be a problem when theoretically the demand for this information exceeds the supply? The answer lies in the effect that information has on an organization or manager. The greater the quantity of relevant information that an organization or manager can acquire, the better the chance that uncertainty surrounding the organization or manager is reduced. Since total certainty is generally regarded as impossible, the demand for information needed to reduce existing uncertainty will always exceed what is available. However, relevant information is lost in a forest of irrelevant or marginally useful information; i.e., "the glut of marginally relevant information is clogging our communications channels and thereby preventing useful information from reaching our decision-makers....it is (therefore) necessary to maximize the effectiveness and efficiency dealing with the use of the information resource." [7: 2, 22]

The development of SNAP can be considered a significant indicator that the marginal information handling capabilities in the Navy are affecting its performance to a high degree. Therefore, information should be managed in the context of a resource management discipline wherein "a resource can be thought of as something observable which can be categorized. A resource is something usable, not only for its original purpose, but extending to a purpose beyond the original one. Finally, a resource to be managed must be collectable and not dispersed within the organization. Management of a resource means that opportunities exist to conserve the resource, to attend to the efficiency and effectiveness of use of the resource and to look for a payoff in the profits of the organization through the effective utilization of the resource itself." [8: 41] Using this frame of reference when implementing SNAP will enable the benefits of automation to extend beyond the predetermined requirements to the arena of management decisions.

The initial step in using the IRM concept is **understanding the nature of information**: "data can be defined as unevaluated raw facts, while information may be thought of as evaluated data, that is, facts which have been interpreted in some manner so as to give them more value than they had in the natural state." [7: 2] Viewed as an organizational resource, information is conceptually similar to

other, traditional, resources (i.e., money, people, and material) because it has value (in terms of time, manpower, etc.), and it has qualities (e.g., time of availability, accuracy, method of display, etc.) which can be controlled. [9: 43-44] Additionally, managers continually find themselves asking the same type of questions about information as they do about the other organizational resources: "What information will I need? When will I need it? How accurate must it be? In what form will it be most useful to me? How shall I organize this information?" [9: 46] To answer these questions, management of the information resource must be "concerned with the policies and procedures which govern the processing and movement of information - such factors as the structure of the information, its content and make-up, its completeness and authenticity, its availability and accessibility, its timeliness and accuracy, and so on." [10: 7] Another way to grasp the idea of information as a resource is by using an analogy of a mineral resource like coal.

Coal: [7: 41-42]

- has an acquisition cost;
- comes in several different grades, some harder and more expensive to mine than others;
- comes in various degrees of purity;
- must be refined and processed to enhance its value;
- passes through many hands from point of acquisition to point of use;

- has many synthetics to compete with - some cheaper, some more expensive;
- can be bought and processed in its raw material form and thus integrated vertically, or can be bought in more refined and processed forms; and
- is subject to the value added principle[3] at each stage in its life cycle; and transfer pricing principles and techniques can be applied as it moves along its path from acquisition to use.

The next step is to establish a management function whose purpose is to "define, measure, package, manage, utilize, and dispose of that (information) resource according to prescribed principles and practices." [7: 43] Since IRM emphasizes centralized management of information to enhance the operations of the total organization, it is evident that coordination across organizational lines is required to support the IRM effort. Aboard Navy ships, SNAP systems will provide a common denominator among the various departments because the computers will be the central repository for machine readable data used by each department. However, the IRM concept concerns the information itself, not the processing of information; and since the information

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[3]"The value added concept of information can be understood by categorizing information into different categories: 1) information for operation, 2) information which enhances operation and 3) information for decision-making. Basic company information collected for operational reasons achieves a value added status when it is also used in decision-making processes. Information gathered which enhances operations can achieve more value when further processed and combined with related information." [8: 42]

needs will be defined for the total organization, the responsibility of IRM would have to be not at the Data Processing (DP) center, but rather at the management level above the departmental level, i.e., the Executive Officer. With IRM responsibilities at the Executive Officer level two important criteria are met. First, involvement and support by top management will be continual. Secondly, the responsibilities of coordinating information flows an ensuring that information policies truly benefit the whole organization are separated from the responsibilities surrounding the mechanics of processing efficient and reliable data. The Executive Officer, as the "boss" over all departments, will sign off on just how information is to be used aboard ship (with the concurrence of the Commanding Officer, of course). The results are that policies are implemented and enforced by top management; and that suggestions, conflicts, etc. are processed up the chain of command rather than across departmental lines through the DP center.

The third step is to develop necessary policies, procedures, and systems required to properly manage the information resource. These policies, procedures, and systems should be published, disseminated within the organization, and include at least the following: [11: 58]

- Statement of overall objectives relating to the overall company objectives and goals.

- New organizational structure and responsibilities of key personnel.
- Policies and procedures for monitoring, controlling, coordinating, and managing of different activities.
- Mechanism for identification and implementation of new requirements.
- Mechanism for feedback from the user community regarding the effectiveness of different activities.
- Mechanism for keeping executive management informed about the developments (successes and failures) in the information processing and handling environment.
- Mechanism for incorporating improvements in any or all of the above mentioned policies and procedures to achieve the stated objectives on an on-going basis.

In summary, the IRM concept views information as an organizational resource (along with men, people, and material), the value of which lies in its use by management to make sound decisions. The key ingredient to develop this resource is the ability of each manager to determine the relevant information needed to get his/her job done. Through the leadership of the IRM "executive," data "litter" will be eliminated and the information needs of the individual managers will be integrated to benefit not only themselves but also the entire organization: "IRM is another way to think systematically about the organization and its objectives. IRM seeks to identify the common patterns of information that exist in the organization, to integrate these varied patterns across the total organization into a

coherent whole, and to provide guidance in the form of standards and conventions to make the best use of information owned by the organization." [9: 46]

III. THE DATA DICTIONARY SYSTEM

A. DESCRIPTION

The essential management tool compatible with the IRM concept is the Data Dictionary System (DDS).* A DDS can be considered a "repository of information about the definition, structure, and usage of data. It does not contain the actual data itself....the data dictionary contains the name of each data type (element), its definition (size and type), where and how it's used, and its relationship to other data." [12: 129] This "data about data" contained in a DDS is termed "meta data." By automating the management of definitions on which systems are built, optimization of data standardization and control can be realized, resulting in improved DP productivity and system reliability. Additionally, headaches associated with traditional documentation strategies, and which plague both an applications environment and a data base environment, can be cured. The problems with traditional documentation strategies can be summarized as follows: [13: 37]

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*Within the context of this paper, a DDS also includes those systems termed Dictionary/Directory (D/D), Data Dictionary/Directory (DD/D), and Data Element Dictionary (DED).

- Management of documentation is largely a manual process which is separated from events or changes occurring within the source or object code of the applications systems it describes.
- There is no automatic guarantee that existing documentation is up-to-date, synchronized with executing system configurations, or accurate in representing the data and system resources of the (organization).
- Managing and motivating the pursuit of comprehensive documentation is a difficult and time-consuming affair.
- For a number of reasons, the resulting material may be difficult to use or ineffective in meeting the dynamic needs of the (organization). Real questions arise about the authenticity of the information it contains.

A DDS espouses centralization and standardization of data. Therefore, it ties in closely with IRM (Chapter I) and DBMS (discussed in the next chapter). However, a DDS is also well-suited for an applications environment. Problems with an applications approach (e.g., data redundancy, unchangeability, inflexibility, etc.[5]) stem from decentralized ownership and control of data and applications processing. However, a DDS deals with data definitions, not data or applications. Therefore, a DDS's centralized data management approach to data definitions will help alleviate these problems of the applications approach by aiding "in the collection, standardization, an dissemination of

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[5]The disadvantages of an applications approach are discussed in more detail in in Chapter IV.

information relative to the different applications system. The use of a DDS will help enforce the development standards concerning data item naming, usage, and coding....The information contained within a data dictionary may be used by almost everyone connected with a software system. A person can locate information needed to learn about a system, a component of the system, or a particular data item within a system." [14: 3]

Meta data is physically stored in a data base. A DDS can be cosidered to consist of two parts: a dictionary and a directory. The dictionary comprises those data definitions generated from the meta data, and which are applied to various applications. The directory permits applications to access the stored meta data without requiring knowledge of their physical locations or characteristics. Thus, the directory is used to enhance the versatility of the dictionary, enabling the DDS to perform the following functions: [14: 3-4]

- Record keeping. The (DDS) will document all of the data items in one or more applications systems. An objective of the documentation is to determine common data elements and reduce redundancy of data within the application system. Additionally, this record keeping will aid in system enhancement and correction, as well as system documentation.

- Cross Reference. The (DDS) will maintain a useful cross-reference between the entities contained in it. A cross-reference will be kept between data elements, synonyms of elements, programs, reports, files, records, and users.

- Indexing. Indexing provides a means to relate words to their definitions. They can either be indexed by key words (e.g., a KWIC Index) or by standardized indexing terms (e.g., a KWOC Index).

- Standardization and Control. The DBA (Data Base Administrator) can exercise management control over all the data elements in the related application systems. For example, the DBA can institute a procedure to review all data items for redundancy and conformance to standards prior to their implementation in the application systems.

A DDS, by its ability to perform the above functions on the meta data, can produce a reliable dictionary that is capable of answering questions posed by the IRM manager such as: [12: 129]

- What kind of validity tests have been applied to this data type?
- Who is authorized to upate it?
- What modules, programs, and systems use this data type?
- What are the valid ranges of values for this data?
- What security level is applied?
- Who is allowed to access the data?
- By what other names is the data type known in various applications environments?
- In what reports does this data type appear?
- What is the input source for this data type?

In order to answer the above questions, a DDS aims at three objectives: [15: 288]

- Inventory Management. The (DDS) provides an inventory of the data that comprise the resource and of

the programs, transactions, and screens used to access the source. The inventory includes names, definitions, locations, storage formats, sizes, and other characteristics. With this repository of information, standards for names, access, storage, security, and validation can be implemented and enforced more easily.

- Cost Control. A (DDS) helps to control the costs of developing and maintaining computer-based applications. A (DDS) can provide an accurate and complete library of data definitions for use both in application programs and in canned program generators such as report writers and query processors. Maintenance efforts can also be facilitated through use of reports generated by the (DDS) that help to predict the effects of change in one part of an information system on other parts of the system.

- Resiliency. A DDS improves the resiliency of the data resource to changes in the data processing environment. Achievement of data independence from the characteristics of a particular hardware and software environment allows the information resource to adapt to changing requirements.

B. CLASSIFICATION

A DDS may be classified in one of two ways. One classification is by the capability of the DDS to provide data entry descriptions to other software. In this context, the DDS can be said to be passive or active. With a passive DDS, the data entry descriptions will exist within the DDS and other software (i.e., COBOL programs) on an independent basis. Therefore, changes in the DDS do not automatically result in corresponding changes in the software containing the appropriate entity descriptions, and execution of applications programs do not include automatic checking with the

DDS for correctness of data definitions. Thus, the DDS in itself does not control definitions of the organization's data. It rather would be the primary reference used to control the definitions manually. [16: 6-7]

On the other hand, an active DDS is the <u>only source</u> for data descriptions used in other processing components such as compilers, assemblers, and DBMSs. Enforcement of data standards and usage throughout the organization's applications, and changes to appropriate software using data descriptions that are changed in the DDS, are accomplished automatically by the DDS instead of manually. As an example, an active DDS, using dictionary information and parameters supplied in the job stream, could produce the DATA DIVISION for any COBOL program without manual intervention. The portion of the program produced by the DDS will be interspersed with the rest of the source program when the program is compiled. Additionally, if the DATA DIVISION was produced manually, it would be automatically verified by the DDS before program execution. [16: 7]

The second classification of a DDS is according to its dependence on other software for implementing its functions. In this respect, the DDS may be termed stand-alone or dependent. A stand-alone DDS is self-contained. Its functions are performed without relying on any other general purpose

software such as a DBMS. A stand-alone DDS may be active or passive. [16: 6, 7]

A DDS that is designed to operate in conjunction with another general purpose software system such as a DBMS is a dependent DDS. This type of DDS requires the facilities of the general purpose software system (e.g., DBMS) in order to perform DDS functions. [16: 7] This type of DDS can be said to be an "in-line" DDS, and it is generally used with a DBMS. Essentially, this in-line DDS is an elaboration of an active DDS in that the DBMS directory serves as the directory for both the DDS (for data definitions) and the DBMS (for the object data requested by the user application). [13: 42]

C. SUMMARY OF BENEFITS.

In summary, a DDS can be considered "a single, authoritative source of information on data elements, their use, and their organization and format. It is a way of monitoring and controlling data resources without actually integrating and centralizing the data itself. Instead, information on data is integrated and centralized in a single file." [17: 32] The centralization and standardization themes of a DDS makes it very compatable with IRM as well as providing the following benefits: [16: 8]

- Better control of the organizations' data resources through improved (i.e., centralized, rigorous, and standardized) data definitions, data handling and data collection procedures.

- Improved transportability of data and software between computing environments through standardized data and data definitions.

- Improved documentation for data bases, programs and systems.

- Automatic compilation of data definitions to be included in application programs or in DBMS data base definitions.

- Increased security and access control for the data base environment.

- Effective aid to software development, modification, and maintenance through configuration management of system components of data and programs.

- Increased cost-effective use of resources throughout the system development life cycle.

The benefits of a DDS direcly impact six major user groups: [15: 289]

- **Data administrators,** who use the system as a major tool for inventorying the data resource, implementing standards, and designing, monitoring, and restructuring data bases.

- **Application personnel,** who use the system to reduce program coding efforts, to store the design of evolving systems and to support analysis of system changes.

- **Operations staff,** who retrieve information about jobs from the (DDS).

- **Data processing management,** who receive high-level impact and summary reports about data usage from the (DDS).

- **End-users,** who obtain descriptions of their data views from the (DDS).

- **Auditors,** who examine and obtain data descriptions for use in auditing software.

IV. FILE MANAGEMENT VS DATA BASE MANAGEMENT

A. PROBLEMS WITH TRADITIONAL FILE MANAGEMENT

As stated previously the traditional file management, or applications approach, is function-(i.e., file) oriented. Data required by a particular applications program (or set of applications) are organized in files based on the requirements of the particular program(s). The objective in this organization is optimization of program performance rather than the information use of the data content of the files. Thus, the result of function-oriented files is the limitation of data, which is probably common to other applications, to the realm of only certain applications. In order for files, containing data that is collected for use by a particular application, to be used by another application, it is necessary to process the files into a different form or format required by the additional applications. [18: 1-1]

The use of a function-oriented approach leads to the creation of several major problems. [19: 9-10] The first major problem is data redundancy. Re-processing of data leads to the occurance of the same data type(s) in several different places. With the same data being stored in

multiple places the chance for development of inconsistencies increases, which in turn impacts data integrity; i.e., it is possible for a data type located in several places to be in different states of update at the same time. The results will be conflicting reports and loss of credibility by users who must use this inconsistent data to make decisions. Additionally, redundant data takes up more storage space in the computer system.

The second disadvantage of traditional file management surfaces when changes to a file system have to be made. If the data format in a file must be changed for some reason, then all of the applications programs which use that file must be located and changed accordingly. Conversely, if the value of a data type in one file is updated, then all files containing that data type must be located and updated. Similar location and verification actions must also be performed for additions and deletions of data types. Therefore it is quite possible that a trivial change to one area of the system can cause a chain reaction of changes in other parts of the system. These changes will be costly in terms of time and personnel.[6]

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[6]This could be a considerable disadvantage with SNAP since one of the program constraints is that no additional shipboard personnel are to be required to operate the computer system.

The next disadvantage is the inconsistency/ incompatability of data/output. As the data in each functional area is defined, different naming conventions may be used (e.g., SSAN, SSN, SOC-SEC, etc. for social security number). Inconsistent naming conventions will tend to confuse users who are unfamiliar with certain representations of a data item. Since programmers maintaining the systems must also deal with this type of data, confusion could lead to delays in developing applications to fit new user requirements. Furthermore, as data between similar systems become more diverse in their definitions and representations, output could become totally incompatable. [14: 2]

A fourth major roadblock is the inflexibility of the applications approach. A prevalent Navy saying is "Stay Flexible," meaning that most day-to-day operations are characterized by unexpected problems and situations which require immediate attention. If decisions regarding these unexpected situations are to be aided by computer generated information using traditional file management methods, the user will quickly find out that data items cannot be re-grouped to fit an ad hoc request without first composing a complete applications program and/or a new set of files. Although the data may exist, information cannot be provided in a timely, efficient manner that can satisfy the user. This situation can be colorfully described by the adage "water water everywhere; but not a drop to drink."

B. DBMS OVERCOMES FILE-ORIENTED LIMITATIONS

It can be deduced from the above discussion that a file-oriented system would be adequate under the following conditions: [18: 1-3]

- Limited scope of management information capability desired.
- High expectation that successful achievement of the file system will satisfy the needs of the organization for a relatively long period of time (5 to 10 years).
- Use of a relatively small volume of data with little growth anticipated.
- Expectation of little or no need for redundancy in the types of data being used.

The static environment depicted by the above conditions does not balance the SNAP requirements of developing a computer system to meet the constantly changing and growing administrative requirements imposed on the Fleet.

Data base management systems (DBMSs) are more adequately suited to meet the challenge of the Navy's administrative requirements because a DBMS is data-oriented rather than function-oriented. This enables the DBMS to integrate data in a manner which enables multiple users to view the same data in different frames of reference without having to create dedicated files or applications programs. In other words, "the data base is designed for generality, for flexibility, and extensibility, both in the design of the various records and in the files that it includes." [18: 1-2]

Many problems existing in the applications approach are overcome by the DBMS characteristic of centralization of data. First, centralized data eliminates data redundancy.[7] With "harmful" data redundancy eliminated considerable savings in storage space is possible. Cost savings are also realized in the updating or modifying of the data base because updates or modifications would only have to be done once. Finally, data centralization results in economies of scale:

- "One person working full time on data problems can be more efficient than twenty people working one-twentieth of their time on the problems." [21: 4]

- The existence of only one data base processing system interacting directly with the data base "implies that the logical and physical structure of the data base, backup, security (and privacy), etc. are under some form of central control. Rather than spreading money and effort across multiple fragmented files, attention can be focused on the single common data base." [22: 136] This means that "more money and analyst time can be spent improving the data base processing system than could be spent on any single file processing system." [21: 4]

A second major benefit of a DBMS is the existence of logical and physical data independence. Logical data

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[7]This is not entirely true. James Martin states that "in reality some measure of redundancy exists in many data bases in order to give improved access times or simpler addressing methods. Some records are duplicated to provide the capability to recover from accidental loss of data. There is a tradeoff between nonredundancy and other desirable criteria, and so it would be better to use the phrase 'controlled redundancy' or minimal redundancy, or say that a well-designed data base removes 'harmful' redundancy." [20: 23]

independence means that "the overall logical structure of the data may be changed without changing the application programs. (The changes must not, of course, remove any of the data the application programs use.)" [20: 30] Physical data independence means that "the physical layout and the organization of the data may be changed without changing either the overall logical structure of the data or the applications programs." [20: 30] The logical and physical data independence provided by a DBMS is necessary if the organization is to consider data, and the information derived from data, as resources (as supported by the IRM concept). With logical and physical data independence users are allowed to create multiple logical views of a single representation of the data. In the context of IRM, users are able to generate information in a variety of forms from the same data. Thus, each user does not have to create separate applications programs and corresponding files because the DBMS is able to re-define the data structures according to the requirements of each application. Additionally, changes to the data itself and to the applications using the data may be accomplished separately with no effect upon each other.

With users only considering their own logical view of the data, they do not have to worry about the data's physical representation, nor about how subsequent changes in the

physical data base will affect their programs. A DBMS uses complex data structures to represent the different logical views of the users; but since the users need not worry about these complex physical representations, navigation through the data base is easy (from the user/programmer point of view) because it is accomplished by the DBMS and not by the program developed by the user.

Another significant benefit of the DBMS is its _ad hoc query capability_, which is based on logical and physical data independence and the dynamic integration of data. By use of a high level query language, unanticipated requests for information can be handled by the DBMS without the need for programming because view definition and navigation through the data base are accomplished by the DBMS, not the user. Therefore, timely information retrieval or report generation is possible on an ad hoc basis. This quick access to information not only improves the quality of a manager's unanticipated decisions, but also programmer productivity by keeping systems programmers from being inundated with requests for new applications and modifications to existing applications.

It can also be noted, in the case of SNAP, that the use of minicomputers also provides an inherent advantage in data base processing because "since their inception minicomputers

have always been oriented to the on-line interactive environment, (and) data base operations also tend to be oriented to the on-line interactive environment.... Obviously, if the hardware architecture and the operating software is interactive, then interactive data base operations are a natural function for the minicomputer. It can be gerneralized that it is easier to run batch operations on an interactive system than it is to make a batch system run interactive applications." [23: SP/26]

In summary, the user-oriented data approach of a DBMS yields advantages to management in the need for fewer personnel; and in faster, more improved responses to information requirements, especially those that are unanticipated. Finally, few information systems used in executive decision-making are immune from new and changing requirements. A DBMS provides the flexibility to respond to changes in a timely fashion by separating the user from the data and by enabling a variety of data relationships to be constructed to conform to different user views.

C. SURVEY PINPOINTS DBMS ADVANTAGES

A survey conducted by Gabrielle and John Wiorkowski of 27 different computer user sites utilizing a variety of commercial DBMSs produced the results shown in Figures 2, 3,

4, and 5. [24] The user sites involved included representatives of industry, government, education and research, and several miscellaneous others. Seventeen sites had their DBMS installed for at least one year. The other ten were newcomers. The advantages and disadvantages of DBMSs listed in Figures 2, 3, 4, and 5 were rated on a scale of 1 to 5, with 5 being the most important and 1 being the least important. Several important conclusions were derived which correspond with the above discussion about DBMSs:

1. Data independence was rated most important. "The users stated that the data organization is transparent to the programmers, that data is removed from the programs, and there is increased ease in programming both during development and during maintenance of an application using a DBMS.

   "As data independence increases, maintenance costs and costs of adding applications should and do increase. Prospective DBMS users can indeed anticipate a decrease in these costs." [24: 109]

2. Data Integrity: "Several users commented that end users really look at the data now as compared to the application's voluminous reports prior to DBMS. The end user will call about an error and a correction can be made immediately." [24: 110] This immediate correction capability is possible through data centralization in a DBMS environment.

3. Two-thirds of the users surveyed (18) were on-line. The average rating of these 18 users as to the on-line benefits was 4.4 (as opposed to the 4.0 average rating listed in Figure 2 which includes the 9 users who were not on-line). Referring to Figure 2 it can be seen that the 4.4 rating of on-line benefits from on-line users is equal to the 4.4 rating given to the most important benefit, data independence. Various responses by the users included:"'being on-line is the most important advantage of DBMS'; 'on-line contributes greatly to the advantage of the data base approach'; 'ease of

programming on-line'; etc." [24: 110] This "closeness" in the ratings is logical since data independence (physical and logical) is required to implement on-line interactive query capabilities.

4. Ad hoc query capability to handle unanticipated requests requires on-line capabilities. Regarding the handling of unanticipated requests, the survey revealed that "the online users had a significantly higher increase (3.2) compared to the off-line users' increase (1.4). The on-line users also believed that the information received from the application on DBMS was considerably more useful (3.1) to end users in their daily activities than the off-line users did (1.4)." [24: 110]

5. Note the decrease in data redundancy in Figure 3.

6. One-third of the users responded that the DBMS replaced more than one application. Additionally, other users stated that applications files had been reduced in number and that several systems that had previously been disjoint were integrated in the DBMS environment.

7. Finally, comparisons of Figures 2 and 3 with Figures 4 and 5 reveal that the benefits with the lowest ratings were more important to the organization than the highest rated disadvantages. The conclusion drawn is that the advantages far outway the disadvantages, and that the disadvantages are not unmanageable.

Advantage	Importance
Data Independence	4.4
Data Integrity	4.3
On-line benefits	4.0
Centralized control	3.8
Ease and flexibility in restructuring and maintaining data	3.7
Reduction in data redundancy	3.6
Integrated vs. independent applications	3.5
Quick handling of unanticipated requests	3.5
Programmers not having to know physical structure	3.5
Security and Privacy	3.1

Strangely, the data base concept is so tightly linked with being on-line that "on-line benefits" appeared as a major advantage of DBMS.

How Users Rate the *Importance of DBMS* Advantages
(on a scale of 1 to 5)

Figure 2 [24: 110]

Advantage realized	Gain or (Reduction)
Data Independence	3.2
Data Integrity	2.5
Centralized control	2.3
Ease and flexibility in restructuring and maintaining data	2.8
Reduction in data redundancy	(1.5)
Integrated vs. independent applications	2.3
Quick handling of unanticipated requests	2.0
Programmers not having to know physical structure	2.0
Security and Privacy	1.2

Other change	
Maintenance costs	(0.7)
Cost of adding applications	(1.7)
Ability to backup and recover	2.2
Number of characters stored	0.8
Timliness of information	2.6
Usefulness of information	2.5

Some changes realized with the installation of a data base management system are actually not directly related to it. Many users claimed, for instance, that backup and recovery was made more difficult by the installation of a DBMS; the gain in recoverability actually came from their being forced into developing better procedures to make the DBMS applications work.

Degrees of Change After Installing DBMS
(on a scale of 1 to 5)

Figure 3 [24: 110]

Disadvantage	Importance
Operational inefficiency	2.8
Additional operating cost	2.4
Cost of additional hardware/software	2.3
Additional cost of storing data	2.0
End user problems in the transition	2.2
Cost of the DBMS	2.1
Cost of installing DBMS	2.0

The disadvantages of running a data base management system, including higher operating costs, were usually seen as less important than the advantages.

How Users Rate the Importance of DBMS Disadvantages
(on a scale of 1 to 5)

Figure 4 [24: 113]

Disadvantage	Increase
Operational inefficiency	1.1
Additional operating cost	1.4
Cost of additional hardware/software	1.1
Additional cost of storing data	0.4

Average increases in major costs and in operational inefficiency were seen as "over 20%" by the installations polled. The low number seen for the increase in data storage costs is somewhat deceiving too, since many users extended their applications when it went on DBMS and saw costs go up by half.

Degrees of Change After Installing DBMS
(on a scale of 1 to 5)

Figure 5 [24: 113]

V. THE DATA BASE ADMINISTRATOR

With the applications approach to automation the center of attention is on the procedures or programs upon which data files are constructed. With the data base approach the center of attention is on the data itself. Since the value of data is proportional to the accuracy of the data, and since most data will be centalized with the data base approach, it follows that centralized definition and control of an organization's physical data base is required for a successful integrated data base environment. The IRM executive is one side of this data control "coin." He is responsible for interpreting organizational policies, goals, and objectives. The IRM function is strictly non-technical in nature.

The technical side of the data control "coin" is the Data Base Administrator (DBA). The DBA is "a human function with responsibility for the definition, organization, protection, and efficiency of the data bases in the data base environment, including responsibility for defining the rules by which data is accessed and stored." [25: 6] The wide range of specific responsibilities assumed by the DBA are listed in Figure 5. These responsibilities of the DBA

DATA BASE DESIGN

- Content
  - Creation
  - Reconciling differences
- Dictionary/Directory
  - Create
  - Maintain
- Data compression
- Data classification/coding
- Data Integrity
  - Backup
  - Restart/recovery
- Retrieval
  - Search strategies
- Statistics
  - Access
  - Frequency of processing
  - Space use
  - User utilization
  - Response time
- Design operational procedures
  - Access to data base
  - Access for testing
  - Interfaces
  - Testing system

DATA BASE OPERATION

- DED custodian/authority
  - Maintain
    - Add
    - Purge
- Data base maintenance
  - Integrity
    - Detect losses
    - Repair losses
  - Recovery
  - Access for testing
  - Dumping
- Software for DED/DD
  - Utility programs
  - Tables/indexes, etc. for end user
- Storage
  - Physical record structure
  - Logical-physical mapping
  - Physical storage device assignments
- Security/access
  - Assign passwords
  - Assign lock/key
- Modifying passwords/keys
  - Logging
  - Cryptography
  - Modification

MONITORING

- Quality of data validity
- Performance
- Efficiency
- Cost
- Use/utilization
- Security/privacy
- Audit
- Compliance
  - Standards
  - Procedures

OTHER FUNCTIONS

- Liason/communications with:
  - End users
  - Analysts/programmers
- Training on data base
- Consultant on file design
- Design operational procedures
  - Access to data base
  - Access for testing
  - Interfaces

Functions of a Data Base Administrator

Figure 6 [26: 185]

are interpreted to fall into five major categories: (1) Data Definition and Data Base Design, (2) Administration, (3) Operations, (4) System Monitoring and Improvement, and (5) General Support. [25: 7]

The Data Definition and Data Base Design function is shared with the IRM executive. The IRM executive ensures that information standards and policies are developed, disseminated, and enforced and that data to be stored in the data base is compatible with the information standards and policies of the organization. The DBA ensures that rules for user access are promulgated and enforced. Integrity aspects include protection of the data base against inaccurate, invalid, or missing data, and security aspects include protection of the data base from purposeful and illegal access, destruction, or dislocation.

The Administration function of the DBA ensures that all the "rules" are being followed; i.e., that organizational, government, and other pertinent directives and policies regarding the disposition of the organization's data are being obeyed, that data base security and integrity standards are being used in day-to-day operations, and that proper documentation of the data base environment (such as the recording of procedures, standards, guidelines, and data base descriptions) is being conducted.

Under the Operations function, the DBA ensures that all resources within the data base environment operate in an efficient and effective manner. Both formal and documented procedures for user access to the data base must be used. Additionally, scheduling of computer time to ensure priority use of the data base, utilization or repair of data base components, and general operational use of the data base must be performed. Other important components of the Operations function include maintenance of the DDS and ensuring that system recovery, and security procedures are properly exercised and controlled.

System Monitoring and Improvement ensures an efficient level of service while effectively maintaining data base integrity. System monitoring procedures measure the performance of both the hardware and software components of the data base environment. The DBA is responsible for reviewing the results of monitoring the computer system, identifying difficulties and inefficient areas of operation, and initiating any activities needed to improve the data base environment. This activity is called "tuning" of the data base.

The final function, General Support, includes the educating of new users in the proper operation of the data base, and the continuing education of present users to

ensure that all components and standards of the data base environment are effectively and properly being used. The DBA is also the point of contact within the organization who should keep abreast of outside developments relevant to the operation and administration of the organization's data base(s) and DBMS. In the case of SNAP systems, the shipboard DBA would liason with the principal shore activity responsible for the direct support of the shipboard comuter systems. This shore activity is the Navy Management Systems Support Office (NAVMASSO). Under SNAP many functional area applications are being developed by NAVMASSO that are standardized for use throughout the Fleet. In a data base environment, strict controls would have to be implemented with the standardized applications so that shipboard personnel could not modify the applications without the authority of NAVMASSO. The DBA is the central personality who can ensure that use of standardized applications is strictly enforced, and who can maintain the necessary liason with NASVMASSO regarding the use of specialized applications as well as the DBMS itself.

The centralized control over data activity (as oppposed to just data) encompassed by the DBA function will result in a data base environment that is more error free than the decentralized environment of the applications approach. Additionally, an atmosphere of standardization will result

which will facilitate the minimization of data redundancy and simplify the sharing of reliable data across organizational lines. However, in order to realize these benefits, the DBA must take on a wide variety of responsibilities (Figure 6) which require close and constant attention. Therefore the DBA should be a primary, full time assignment.

VI. CONCLUSIONS

The U.S. Navy is in a constant state of growth in order to meet its goal of 600 ships. The result of this growth is added complexity in both the operating and managing of ships. Automation with computers has enabled newer ships too steer, fight, and be propelled, without the need of human intervention, resulting in reduced manning levels aboard ships. The combination of increased Fleet activity and reduced ship manning levels has resulted in a severe administrative burden upon shipboard personnel which significantly affects ship performance and personnel morale and retention. The purpose of the Shipboard Non-tactical ADP Program is to alleviate much of this administrative burden through the employment of non-tactical computers.

The first requirement in developing any system is to define the objectives. It is the premise of this paper that the objectives of SNAP only address the short term because the intention of SNAP is to satisfy certain pre-determined functional needs of the Fleet; and to compensate for the unfamiliarity and inexperience of shipboard personnel with the procedures required to maintain a DBMS environment in a reliable state. The result is an applications approach to

SNAP system development, with no planning or development being conducted for eventual transition to a data base environment. If what has already been defined is all that will ever be required of the SNAP systems, then the applications approach will probably be better than the data base approach: "It is quite common for a DBMS to be used to solve a particular problem with the intention of having no impact on the company. However, there is a danger that using a DBMS in this way can result in its use increasing in an uncontrolled way, often resulting in disasterous consequences." [27: SR/4] However, the administrative environment in the Fleet is constantly active in that new requirements are created and already established requirements are changed or updated. Additionally, familiarization with the SNAP systems will encourage their use beyond the scope of the pre-defined functional needs.

An applications approach is a "brute force" method for meeting the increased information requirements in the Fleet. The increased capicty to process data will be realized; but the static and unchangeable characteristics of the applications environment tend to make data inaccurate, inconsistent, or outdated because data: [6: ID/21]

- Is stored in different formats.
- Is often not shareable, necessitating redundant files.

- Is often not easily recoverable or secure.
- Usually has structure tied directly to program logic.

The result will be the inability to generate the necessary information for the on-going success of the organization. A move from processing data with an applications approach to producing information with a data base approach will have to be made. [28: ID/9]

The second intention of SNAP (compensation for lack of knowledge of shipboard personnel in ADP) is based on technical and training limitations. Figure 6 illustrates a multitude of functions to be performed by the DBA, the most critical of which are: (1) backup and recovery, (2) privacy and security, (3) concurrency and deadlock control, and (3) auditing. The proper operation of a computer system depends on the effective impelementation of these functions whether computer system development follows an appliactions approach or a data base approach. "The integrity of the data base may be affected by a software, a hardware, or operator malfunction. The malfunction may be of a magnitude serious enough to either completely destroy the data base or to leave it in a state that its contents cannot be vouched for. It is therefore necessary for the system to possess the ability to recover from such a malfunction while maintaining the completeness (or integrity) of the information held

within the data base." [29: 110] Admittedly these functions are more complex in a data base environment than in an applications environment. However, the key to success in either environment depends not upon the relative complexity of the two approaches, but rather upon the proper education, training, and management discipline used by personnel designated to implement and operate the systems.

To illustrate that the disadvanatage of user inexperience with a DBMS is a short term effect which can be overcome using sound management and training techniques, consider a representative function of the DBA - backup and recovery. Referring to Figure 3 in chapter IV., the ability of the surveyed organizations to backup and recover as a result of implementing a DBMS increased by 2.2 on a scale of 1 to 5. As the figure notes, complications with backup and recovery were initially experienced with the use of a DBMS. However, these complications were overcome by development of better procedures, with the net affect being positive. As a supplement to this observation by the Wiorkowskis, Ian B. McCririck and Robert C. Goldstein surveyed 555 large computer users in Canada both the public and private sectors regarding the functions of the data administrator. Responses were received from 43% (253) of the sample, and 71 claimed to have an explicit data administration function. In response to the question of how the time spent on each

data administrator task was expected to be different two years later, "the majority of the respondents felt they would be spending more time in two years on every responsibility on the list. Only one item got the votes of as many as 10% of the DAs for becoming less important - the development of backup, recover, and restart procedures." [30: 134] The results of these two surveys infer that once sound procedures and standards are defined, and proper training conducted, technical limitations are steadily corrected, resulting in increased performance.

After SNAP implementation is complete, usage of the system will result in increased experience and knowledge in users as to the true capabilities of the systems. Increasing requirements upon the SNAP systems will be focused beyond the pre-determined functional needs into the area of aiding the management decision-making process. This means that certain information from each department of a ship will have to be accessible to all other departments so that the "information resource" of the ship can provide maximum benefit to total ship performance. Access to a ship's information resource will have to be timely and reliable. This will be accomplished by on-line capabilities of the computers, including high level query languages.

The dual requirements of fulfilling certain functional needs now and decision-making needs in the future cannot be provided for by a traditional file management system because the applications approach is only function-oriented. The data base approach will evolve because it can fulfill both types of needs. This is because the data base approach is oriented to the common denominator of the two types of needs - the data itself.

As the need for a data base approach becomes more predominant, the administration of a ship's information will require the use of Information Resource Management. The best technical implementation of the IRM concept is a Data Base Management System because IRM and DBMS both support the same philosophy: centralization and standardization of both data and the control of data.

A common management tool will be needed to bridge the gap between the management of data and information, and the automation of data and generation of information. This tool is the Data Dictionary System. The concepts underlying both IRM and the operation of a DBMS can be explicitly documented and implemented with the aid of a DDS. The compatability of IRM, DBMS, and DDS is summarized in Figure 7.

Finally, management positions will have to be established to enforce absolute authority in the definition and

use of a ship's data. These billets aboard ship will be an "IRM executive" and a "DBMS executive." The IRM responsibilities will fall upon the executive officer, and the DBMS responsibilities will be carried out by a shipboard Data Base Administrator. The number and variety of functions to be performed by the DBA dictate that the data base administrator function will have to be a primary billet.

Data Resource Management Goal	DBMS Function	Data Dictionary Function
To build and control corporate data resources.	Management of corporate data resources.	Management of the definitions and documentation for corporate data resources.
To organize models of corporate information.	Physical support for relationships between data that is meaningful to the corporation.	Support for documenting the types of information within corporate data resources, as well as the system components that support them.
To improve the accessibility of corporate information.	Physical support for data access, by keys and inter-record relationships.	Support for investigating the types of corporate information available, as well as the means by which they are supported.
To increase the longevity of system and data resources, to facilitate their maintenance and enhancement and thus to protect the corporation's investment in them.	Separation of logical and physical data base views, making application programs independent of changes in data organization and making new applications easier to implement.	Provision of tools to accurately asses the specific impact of data and system changes and to determine what the content and extent of existing resources are.
To improve the accuracy and consistency of corporate information.	Elimination of data redundancy through systems-supported methods of data integration.	Elimination of the artificial segregation between system documentation and system driving definitions.

Comparison of DBMS and Data Dictionary Functions, With a Common Classification of Data Resource Management Goals

Figure 7 [13: p. 37]

Data Resource **Management Goal**	DBMS **Function**	Data Dictionary **Function**
To bring coordination and consistency to information system implementation efforts.	Centralization of data definition.	Centralization of definition management standards enforcement, naming procedures, and modification control.
To improve the productivity of the data resources staff.	Provision of programming tools to implement complex application problems, while isolating systems from the impact of change.	Provision of programming aids, such as ready made data definition and trustworthy impact assessment tools.
To protect the data resource.	Support for access security and data base integrity, backup and recovery.	Support for protection of all definitions on which information systems are built.

Figure 7 (cont.)

VII. RECOMMENDATIONS

The recommendations cited in this section are made under the assumption that SNAP implementation will not be employing a data base approach. Since it is predicted that the increased knowledge and experience on part of the end users of the SNAP systems will generate requirements to utilize the SNAP systems for more diversified, management-oriented applications in support of the decision-making process, it is necessary that planning begin now for development of a data base environment for non-tactical ADP support aboard ships.

A. MANAGERIAL RECOMMENDATIONS

The initial step in developing a data base environment is the education and training of the managers whom the computer systems will affect; i.e., the officer corps. The data base approach is characterized by the centralization of data and its control. Commanding Officers, Executive Officers, Department Heads, and Division Officers all receive formal classroom training before reporting to their respective billets. Fundamentals of the Information Resource Management concept must be addressed during this

classroom training of shipboard managers: (1) information is a resource that directly affects the performance of the ship in carrying out its mission, and should therefore be managed with the same considerations given to other resources; and (2) the data required to generate administrative support information is coordinated and controlled "at the top" (i.e., the Executive Officer) rather than at lower levels of management. This prevents data from becoming proprietary as well as enforcing top management involvement in producing the "team effort" required to ensure successful performance.

The second important step which should be taken now is the establishment of a Data Dictionary System for the applications presently being developed and implemented under SNAP. The central repository of data definitions, controls, and standards contained in a DDS is invaluable to the proper management aboard ship. The DDS theme of improving the authenticity of information, or documentation, about an organization's applications systems sets the stage for implementing the IRM concept in a data base environment. Secondly, a DDS provides a common denominator between the ship and their primary shore-based support activity, NAVMASSO, when help or consultation is required regarding SNAP operations. As confidence in automation increases and a data base environment begins to evolve, the DDS will be the primary tool used for systems development.

Because a passive DDS places considerable demand for overt and extensive DBA involvement in many system support activities in order to ensure the dictionary's viability as an accurate system and data documentation tool, it is recommended that a passive dictionary be constructed for two reasons: (1) it is inherently less complex than an active dictionary; and (2) considering that many applications are being devloped centrally for use throughout the fleet on equipment furnished by different contractors, the portability of a single, centrally developed DDS would be enhanced. It is most likely that two central DDSs would have to be developed if they were active because "the strongest potential for the development of an active system, at least theoretically, is where the same vendor supplies all components of the overall data management complex, including the host language compilers, the DBMS (and its compilers) and the DDS. This, of course, normally means the hardware vendor." [13: 42]

The third managerial recommendation addresses the SNAP constraint of no additional personnel being required to operate the SNAP systems. Aboard ship, this constraint will foster assignments to data management and operations on a collateral duty basis. The operation, maintenance, and control of a data processing environment, which will greatly impact the way in which a ship does business, will require

attention to detail and follow-through abilities. These key characteristics of effective management can only be realized by assignment of personnel on a full time basis. At a minimum the person in overall charge of the data processing "department" should be an officer. This person would essentially be serving as the ship's Data Base Administrator for the ship's non-tactical ADP support, and as such should be given the status of a department head accountable to the Executive Officer.[8] Given that personnel experienced (or even educated) in data processing are not prevelant enough to fill all required billets, training for officers in data processing will have to be part of the training "pipeline" prior to reporting aboard a ship. Also, a pool of formally educated officers exist who have completed masters degree level education at the Naval Postgraduate School in Computer Systems Management (18 months) and Computer Science (21 months).

The fulfilling of management decision-making needs encompasses subordinate functional needs. Therefore a data base approach is a more sound approach to realizing both short-term and long-term benefits of non-tactical ADP

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[8]The DBA function performed by the individual aboard ship would have to be a subset of a centralized Fleet DBA function (located at NAVMASSO) because the initial applications are standardized for implementation throughout the Fleet.

support. As such, a data base approach should be instituted from the beginning in lieu of an applications approach. Later conversion from an applications evvironment to a data base environment will be costly and disruptive: "There is no doubt, however, that providing you gather the necessary expertise and have total management commitment that the path of least resistance is in the development of a totally new system." [27: SR/4] Additionally, a DBMS installed under the data base approach will provide the ability for improved management decisions by providing faster responses to unanticipated requests in more user-friendly manner than applications systems.

The testing of a DBMS environment should be performed prior to mass implementation in the Fleet. The establishment of prototype systems for both SNAP I and SNAP II, preferably at NAVMASSO, should be accomplished to facilitate systems development and training. A DBMS should be developed on these prototypes so first-hand experience of the benefits of a DBMS can be experienced. Standardized procedures and training methods can be developed in crucial functional area such as backup and recovery, concurrency control, privacy, security, monitoring, auditing, and tuning.

Finally, plans and shipboard test platforms should be established to incrementally implement the DBMS environment

aboard ship. An evolutionary approach to implementation is necessary to preclude an atmosphere of "too much too soon," where users not accustomed to ADP would be overwhelmed with new technology and procedures. The present applications approach that is being used for SNAP is not considered to be a necessary step in developing a DBMS environment because the foundations upon which the applications approach is based (function oriented and decentralized) are not compatable with the the foundations of the data base approach (data-oriented and centralized). Therefore systems development should be based on a DBMS from the start. A method for incremental implementation of SNAP I has already been presented: [31: 4-3]

> The initial implementation of the systems would be a transaction-driven batch system. The initial implementation of the systems would offer on-line inquiry, but not on-line update. All updates to the system would be performed in a batch mode. The only reduction in capabilities would be the deferral of the on-line update parts of the system. Accordingly, all requests that require updates to the data base would be performed in a batch only mode. Data entry would initially be performed at the central ADP center. Once Remote Processing Systems (RPSs) are installed at other locations in the ship, data entry (still for batch updates) could be gradually shifted to those locations and away from the central ADP center. Since on-line update is not involved, data entry would not adversely effect the response of IMMS-RT and SUADPS-RT. By performing updates in a batch-only mode, the problems of backup and recovery as well as integrity checking procedures are significantly reduced. The systems could still be supported by a DBMS, thus providing the developers and the users of the systems with all of the DBMS advantages outlined above.

The benefits provided by an incremental approach include the following: [31: 4-3]

- Ships will not initially require a fully trained DBA staff aboard.
- Fewer program runs will be required to maintain the system current for the end-users.
- The new technology will be introduced to the shipboard environment in an evolutionary manner.
- Upgraded software can be delivered to fleet units earlier than fully capable applications systems.
- Training impacts will be reduced.
- Developers, users, and operators will "grow" with the new systems, just as is done in industry, albeit at a more accelerated rate at this point in time.

B. FILE AND RECORD STRUCTURING USING NORMALIZATION

The significant managerial considerations of IRM, DDS, and DBA presented in this paper are important for efficient and effective use of ADP support in an organization regardless of whether an applications approach or a data base approach is used. It has also been explained that the data base approach using a DBMS is significantly better than the applications approach in supporting these managerial concepts. However, there is also a <u>technical</u> aspect of ADP development which also applies to both the applications approach and the data base approach, which is also more compatible with the data base approach than with the applications approach, and which can be viewed as the <u>technical</u>

foundation for the above managerial concepts. This technical aspect is known as normalization of file and record structures. Use of normalization enables file and record construction to be accomplished independently from program logic and storage mechanics, thus resulting in: (1) the simplest possible representation of data, (2) minimal duplication of data values; and (3) better machine performance (e.g., when a data item is updated, fewer records must be read and written).

One operational affect upon the manager is the preservation of old views of data when new associations between data items are added, or new usage patterns occur. Consequently, the rewriting of programs to conform to new associations or usage patterns is prevented. Possible disruptions to a program would occur if, for instance, new associations or usage of data force the splitting of records or the changing of record keys. [20: 231]

Disruption of user applications can also be the cause of one or more anomalies associated with faulty file and record design. Explanation of these anomalies can best be understood by referring to a simple example file named SUPPLIERS. SUPPLIERS consists of the following fields:

SNAME	SADDRESS	ITEM	PRICE

The first anomaly is redundancy. The name and address of each supplier must be repeated for each item. The second anomaly, update, follows from redundancy. If the address of a supplier were to change, it is possible that it will be changed in one record and not another. Thus, there would not be a unique address for each supplier as expected. The other two anomalies are insertion and deletion. In the SUPPLIERS file information about a new supplier cannot be entered independently of the item(s) sold. Conversely, if a supplier only appears once and for some reason the corresponding item sold is no longer considered relevant to a particular application, the deletion of the record based on the ITEM value will also delete the name and address information about that supplier. Referral to that supplier in the future regarding a different item would not be possible. [32: 166-167]

The normalization process is a stepwise process which reduces complex file and record structures to simpler structures that inherently minimize potential disruptions to user applications. Complex structures (those which contain repeating fields or groups) are considered non-normalized.

From the initial non-normalized forms, files are simplified in three steps, the products at each step being first, second, and third normal form files, respectively. The third normal form is considered optimum.

Normalization is based on the concept of functional dependency. We say that "item B of data record D is functionally dependent on item A of D if, at each instant of time, each value of A has no more than one value of B associated with it in data record D. In other words, item A is said to identify item B." [33: 117] Symbolically, A -----> B is read "A functionally determines B," or "B is functionally determined by A." Also, A --/--> B is read "A does not functionally determine B," or "B is not functionally determined by A." In the SUPPLIERS file, the following is true:

SNAME -----> SADDRESS

SNAME ITEM -----> PRICE

ITEM --/--> SUPPLIER

PRICE --/--> ITEM

The first normal form is generated by removing all repeating fields or groups. This simplifies the file structure by shifting the logical representation of relationships from variable length records to fixed length records. Normalization into second and third normal forms will be demonstrated using the following file: [33: 118]

File Name: ORDERS

ORDER-NR	PRODUCT-NR	CUSTOMER-NAME	CUSTOMER-ADDRESS	CREDIT-RATING	QTY-ORDERED

ORDERS is already in first normal form and the record key is the concatenated key ORDER-NR PRODUCT-NR. Analysis of the ORDERS file yields the following functional dependencies:

ORDER-NR PRODUCT NR -----> QTY-ORDERED

ORDER-NR -----> CUSTOMER-NAME

ORDER-NR -----> CUSTOMER-ADDRESS

ORDER-NR -----> CREDIT-RATING

A record is said to be in second normal form when all non-prime attributes[9] of first normal form files are fully dependent on the record's entire key (including concatenated keys). In the above record structure only QTY-ORDERED is functionally dependent on the entire record key ORDER-NR PRODUCT-NR. With all other non-prime attributes the item PRODUCT-NR is not required for determining their functional dependence. Therefore this structure is not in second normal form. Second normal form files can be created by breaking the source file into two separate files as illustrated below:

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[9]A non-prime attribute (field) is one that is not part of the record key.

File Name: ITEM-ORDERED

PRODUCT-NR	ORDER-NR	QTY-ORDERED

File Name: WHO-ORDERED

ORDER-NR	CUSTOMER-NAME	CUSTOMER-ADDRESS	CREDIT-RATING

Third normal form files are attained when all transitive dependencies[10] are removed from second normal form files. In the file WHO-ORDERED, ORDER-NR -----> CUSTOMER-NAME is true. However, CUSTOMER-NAME -----> CUSTOMER-ADDRESS and CUSTOMER-NAME -----> CREDIT-RATING are also true. Therefore, by the definition of transitive dependency, ORDER-NR -----> CUSTOMER-NAME and ORDER-NR -----> CREDIT-RATING are also valid. These transitive dependencies can be eliminated by forming two new files. These third normal form files are:

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[10]Transitive dependency exists when one or more nonprime attributes (fields) depend on the record key only via another nonprime attribute. Assume A is the attribute or set of attributes making up a record key, and B and C are nonprime attributes. If A -----> B and B -----> C are true, then A -----> C is also true.

File Name: ORDER

ORDER-NR	CUSTOMER-NAME

File Name: CUSTOMER

CUSTOMER-NAME	CUSTOMER-ADDRESS	CREDIT-RATING

The above examples show how simplicity and integrity can be built in to file/record design through normalization. It can also be seen that the normalized files tend to take on global interpretations. In other words, these files are generalized so that the data no longer applies to a single application. This characteristic makes normalization more compatible with the data base approach than with the applications approach.

Although many benefits are derivable from normalization, something is lost when the source records are broken up; namely the relationships between the data that constituted the source records. In the SUPPLIERS file, normalization requires the splitting of the file into two new files, one containing SNAME and SADDRESS, and the other containing ITEM and PRICE. However, once these fields are separated it is not possible to know which supplier supplies which items.

With the applications approach, the user must have knowledge of file construction in order to develop programs. Therefore, the physical representations are synonimous with the logical representations. This means that the broken relationships must be corrected on the record level. A remedy is to retain the key of the source record (SNAME) as the key of the new file containing SNAME and SADDRESS; and also make this key a candidate key[11] of the new file containing ITEM and PRICE, the result being a new file containing SNAME ITEM PRICE rather than just ITEM PRICE. Note that redundancy of SNAME is necessary (in the file containing SNAME ITEM PRICE) in order to correctly normalize the source file.

With a DBMS such compensation does not have to be accomplished at the record level. Through the Data Definition Language of the DBMS, the user can define the relationships between the normalized files in a high level language, and the DBMS will automatically match the suppliers in the one file with the items in the second file. This removes the

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[11]A candidate key is a group of one or more fields that functionally determines a record occurance. Additionally, all of the fields constituting the candidate key must be required to functionally determine a record occurance; i.e., given a group of fields that constitute a key of a record occurance, if any subset of that key can also functionally determine that record, then the original key is not a candidate key.

user from the physical representation and prevents the necessary redundancy of the applications approach (e.g., a DBMS will construct its own variable length files and/or use pointers).

As evidenced from the above discussion, continuity of data and programmer productivity can be greatly enhanced by good file/record design; and good design is accomplished through normalization. Therefore, normalization of SNAP files is strongly recommended because it will result in simpler, standardized data files, and it will contribute to smoother transition to a data base environment in the future, if a data base approach is not used initially.

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